

### A Mounting Arrangement and Method

5 The present invention relates to mounting arrangements  
for and methods of machining components such as turbine  
discs and compressor discs which may retain residual  
stresses after initial forging.

A number of components are initially cast or forged  
into an approximate shape for the final finished component.  
10 Such an approach allows ease of manufacture as well as  
potential crystallography and material treatment to be  
achieved conveniently. The forged component such as a  
turbine disc is then machined appropriately in order to  
achieve the final component shape and surface finish.  
15 Generally the original forged component only provides a  
rough approximation to the final finished shape and so a  
significant proportion of the forged material must be  
removed in order to achieve the desired finished shape.

Machining of the forged component is typically through  
20 milling, turning or broaching whereby material is removed  
from the rough forged component until the desired finished  
shape is achieved. For example, Heyligenstaedt four-axis  
turning machines are known for providing the final  
machining of rough forged components into desired  
25 compressor discs. Unfortunately, these machines are  
designed for high accuracy operation such that multiple  
abutment clamping of the component is necessary and  
normally a datum such as a flat surface is initially  
provided to the component to ensure surety of position and  
30 therefore machined accuracy in the final product. Such  
robust and accurate assembly as indicated is highly  
beneficial with regard to high accuracy machining processes  
but with regard to machining initially rough forged  
components may be detrimental.

It will be understood that forged components generally retain residual stresses arising from the forging or casting process. These residual stresses cannot be relieved in the above forged component due to the high strength clamping inherent in machines such as Heyligenstaedt four-axis turning machines for accurate forming. In such circumstances, when the multi abutment clamping is released the final machine component may become distorted as these residual stresses are then relieved. Such distortion clearly detracts from the desired shape profile for the component in its finished state.

According to one aspect of the present invention, a mounting arrangement for simultaneous machining of opposite faces of a component which may retain residual stresses comprises multiple point contact abutment clamping in use of a component, the arrangement characterised in that only three clamp pairs are provided to enable residual stress relief in use as the component is machined and incorporating a damper to augment vibration control otherwise diminished by the reduced contact clamping provided by only minimal contact abutments.

Each clamp pair is preferably provided by opposed pairs of a clamping pad and seating pad either side of the component. The clamping pad and the seating pad may be configured for consistency with the presented component profile. Such consistency may ensure appropriate approximate configuration of the component within the mounting arrangement.

Each contact abutment may be adjustable in terms of presentation relative to the component. The damper may be perpendicular to the axial direction of contact abutment.

The damper may comprise a hydraulic ram and a damper member, the damper member being held in contact with the component by a force. The force may be variable. The force

applied by the damper may be controlled dependent on sensed vibration or machining process step/regime or current process step, or to facilitate an anti-phase cancellation oscillation within the component to harmonic vibration beats.

The damper may comprise a contact finger of elastomeric material.

According to a second aspect of the invention, a method of simultaneously machining opposite faces of a component which may retain residual stresses comprises clamping the component with multiple point abutment contacts and thereafter machining the component, the component being clamped by only three clamp pairs and a vibration damper being applied to the component in order to augment vibration control otherwise diminished by reduced contact abutments.

The method may comprise an initial machining process for removal of bulk material from a rough initial component and a final machining process with more resilient clamping of the component for more accurate machining of that component.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings in which:-

Fig. 1 is a schematic half cross-section of a mounting arrangement about a centre line X-X;

Fig. 2 is a schematic plan view of a whole mounting arrangement in the direction X-X depicted in Fig. 1; and,

Fig. 3 is a side view of the arrangement depicted in Fig. 2.

Referring to Fig. 1 which is a schematic cross-section of a mounting arrangement 1 in accordance with the present invention. Thus, the arrangement 1 comprises a clamp pair formed by abutment contact between a clamping pad 2 and a

seat pad 3. The clamp pair creates a contact abutment in order to clamp a component 4. This component 4 as illustrated in Fig. 1 is initially a rough forged component with an outline profile 5 but upon machining by means not depicted is rendered with a finished profile 6. Such machining can be by turning or other technique as required. The component will be turned relative to a tool.

In order to provide clamping force an axial movement in the direction of arrowhead A is provided such that contact abutment is achieved between the clamping pad 2 and seating pad 3. Generally, this axial movement in the direction of arrowhead A will be through a screw thread 7 driven by a worm gear or otherwise in order to create the necessary clamping force across the pair of clamping pad 2 and seating pad 3.

In accordance with the present invention a damper 8 is provided which engages the component 4 in order to achieve vibration control. The damper 8 comprises a hydraulic ram 9 with a damper member 10 extending downwards into contact with a surface 11 of the component 4. Thus the damper 8 will damp vibrations created within the component 4 as it is machined from the initial rough forged profile 5 to the finished profile 6.

In accordance with the present invention a minimum number of clamp pairs are provided in order to allow relief of residual stresses created within the component 4 as a result of the forging or casting process. The minimum number of clamp pairs is three. Contact abutments created across opposed clamp pairs will normally be arranged with a 120° angle between clamp pairs, as the component 4 is round. The number of clamping pairs provided will be three to present the component 4 to the appropriate turning device rather than resiliently secure consistent presentation of that component 4 throughout machining for

accurate determination of the final profile 6. In such circumstances residual stresses within the component 4 can be relieved by slip movement or other relief about the pads 2, 3 and between the clamping pairs created between the clamping pads 2 and seating pad 3. Residual stresses can be relieved during machining and upon release of the finished or part finished component from the present clamping pairs there is less distortion of that component from the final machined shape 6.

10 In previous systems eight or more clamping pairs have been provided in order to mount the component with sufficient resilient strength for consistent presentation but such resilient securing of the component 4 prevents relief of residual stresses in the component 4 during  
15 machining processes.

By provision of the minimum number of clamping pairs to present the component to the machining device it will be understood that the component is thereby able to adjust in order to release the residual stresses caused by the  
20 forging process but also unfortunately will tend to vibrate to a far greater extent. Thus, the damper 8 augments vibration control previously achieved through multipoint contact abutments with generally in excess of eight clamping pairs. In such circumstances the detrimental  
25 affects of vibration within the component 4 as it is machined from the initial rough profile 5 to the finished profile 6 are inhibited. Vibration itself may cause erroneous machining of the component 4 so that such vibration control is necessary.

30 The present invention provides a "looser" presentation of the component 4 to the machining device to allow relief of residual stresses but incorporates provision of a damper 8 in order to control vibration in association with the

remaining clamping abutment contacts across a mounting end of the component 4.

Referring to Figs. 2 and 3 which schematically illustrate the mounting arrangement 1 in accordance with the present invention. Thus, three clamping pairs constituted by pads 2, 3 are provided to support the component 4 in an appropriate orientation so that the component 4 may be turned in order to machine an area 20 to an appropriate profile. As indicated previously, the component 4 is generally rotated about an axis X-X. By providing three clamping pairs at equal spacing around the component 4 it will be understood that the component is thereby reliably mounted but with an ability to adjust for stress relief. Typically, the component 4 will be a disc secured within a substantially vertical orientation with turning tools extending inwardly to machine the area 20. These tools would be presented in an opposed orientation either side of the component 4 for balance. Generally, the clamping pairs will be adjusted to ensure appropriate vertical presentation of the component 4 for turning and machining purposes. As indicated in Fig. 3, generally the turning process will remove material from areas 21 in order to shape the component 4 appropriately.

Three or more damper members 10 are generally associated in physical contact with component 4 in order to provide vibration control. As indicated above, such vibration control and contact can be through any appropriate association such that the members 10 may be metal fingers or elastomeric contacts in appropriate engagement with the component 4. Damping control in accordance with the present invention is necessary due to the much reduced resilience provided by only the minimal three clamping pairs provided.

Although only three clamping pairs are utilised in accordance with the present invention, it will be appreciated that these pairs will still hold the component 4 and so inhibit relief of some stress retained within the component 4 as a result of the forging or casting process. In such circumstances, it is preferred in accordance with the present invention to initially turn the component held by the three clamping pairs to an approximation of the desired final profile. Generally, this approximation will be within less than a millimetre of the desired final profile. Once in the approximation to the final profile the clamping pairs through pads 2, 3 will be released to allow the component to relax. This relaxation may result in the component 4 expanding due to stress relief. Clearly, different components 4 will require different periods of time in order to relax for stress relief but nevertheless, after an appropriate period the component 4 will be remounted within the mounting arrangement 1 with the three clamp pairs and the component then finally turned to the final desired profile 6 (Fig. 1).

As the component 4 is mounted by the clamping pairs through pads 2, 3 it will be understood that a rim periphery area 22 of the component 4 cannot be machined due to interference with these pads 2, 3. In such circumstances, normally the component 4 will be released from the present mounting arrangement 1 and mounted in an alternative arrangement to allow appropriate machining of the component 4 in this area 22. This machining may include milling, broaching or other techniques in order to create appropriate rim structures for the component 4. Normally, the rim structure of the component 4 will have a much greater cross-sectional diameter in comparison with the relatively thin area 20 turned into a final profile whilst in the mounting arrangement 1. Thus, such more

substantial structural thickness for radial dimension will limit the effects of residual stresses within the component in this area 22 of the component 4.

In view of the above, it will be appreciated that  
5 machining of a component 4 in accordance with the present invention will typically be of only two major operation cycles. A first utilising the present mounting arrangement 1 with only three clamping pairs in order to create the thin central wall of the component 4 in the area 20 and a  
10 second operation cycle in order to create the rim structures such as blade mounting grooves, etc.

As indicated in Fig. 1 generally the damper 8 is arranged to be substantially perpendicular to the component 4. Such an arrangement is convenient in terms of  
15 accommodation within the clamping arrangement 1 and as depicted in Fig.1 is generally consistent with the major plane of the component 4. In such circumstances, the damper 8 will provide appropriate vibration control without impinging upon the surfaces of the component 4 which must  
20 be machined from the initial rough profile 5 to the final profile 6.

The damper 8 as indicated previously will typically comprise a hydraulic ram which extends the damper member 10 towards the surface 11 of the component 4. The force  
25 supplied or vibration absorption achieved through the damper member 10 and ram 9 may be variable. Such variability in vibration absorption and therefore control will render the clamping arrangement 1 more effective with regard to actual vibration rather than predicted vibration.  
30 In such circumstances, the force supplied through the hydraulic ram 9 in order to create vibration control may be determined through sensing vibration within the component 4 and/or machining device process schedule in terms of current machining step as well as predictive anti-phase



vibrations presented through the damper member 10  
cancelling vibrations within the component 4 caused by  
machining operations. Possibly, the damper member 10 will  
be made from an elastomeric material such as rubber but any  
5 device which can engage into vibrational contact will be  
acceptable.

As indicated previously the number of clamping pairs  
which form contact abutments in accordance with the present  
invention will generally be limited to three which is the  
10 minimum to present the component 4 for appropriate  
machining but with sufficient laxity to allow the residual  
stress relief within the component 4 through the machining  
cycle. In such circumstances as described the minimum  
number of contact abutments is generally three in an  
15 approximate 120° relationship to each other. However, the  
specific number of contact abutments may be determined by  
actual requirements with the damper 8 supplementing in  
terms of vibration control and under performance by the  
reduced robustness of such clamping compared to previous  
20 arrangements.

A number of dampers are normally provided in  
engagement with the component 4 in order to achieve  
appropriate vibration control in association with the  
abutment contacts in clamping pairs in accordance with the  
25 present invention. The positioning of dampers may be  
determined by the particular shape of the component 4.

The present invention also incorporates a method of  
machining components from a rough profile 5 to a final  
profile 6. The method incorporates mounting the component  
30 4 in a clamping arrangement 1 such that there is the  
minimum number of contact abutments provided as opposed  
clamping pairs to present the component 4 for appropriate  
machining. Dampers 8 are then presented to the component 4  
in order to augment vibration control achieved by the

clamping pairs. In such circumstances, the component 4 subjected to the turning process can relieve residual stresses formed within the component 4 during initial forging or casting processes. The dampers 8 prevent vibration diminishing significantly machining accuracy to the final profile 6. In such circumstances, when the component 4 in the final profile 6 is released from the clamping arrangement 1 the residual stresses within the component have not been retained by the clamping arrangement 1 and so there is less if any distortion of the final profile 6 compared to the desired profile. However, advantageously, the method of the present invention may be used in order to achieve approximation of the final profile 5 using the present method in a first step and mounting arrangement and then the component 4 transiently released from that mounting arrangement and re-secured for a second step of accurate fine turning to the final profile 6. In such circumstances the bulk of residual stresses within the original component 4 and profile 5 are relieved by the present method.

Also in accordance with the present invention there is provision for further machining of the component 4 in order to create rim structures. Thus, the component 4 will be mounted in accordance with the arrangement 1 in order to provide initial turning and machining of the component 4 to the desired profile and then these mountings released and the component 4 mounted in an alternative arrangement in order to provide for machining such as milling, broaching or another technique in order to create the rim structures as required. In such circumstances, the component 4 is appropriately machined by substantially only 2 machining processes as compared to the far greater number of machining stages previously. It will also be appreciated

that other structures could be machined into the component 4 in addition to rim structures.

5 The present invention allows by the arrangement or method accurate machining of a component 4 to a final profile 6. Previously, in order to avoid the problems of distortion due to residual stresses within the component 4 it was not unusual to machine a component 4 in four or more processing steps whereby the component 4 is initially machined and then released to allow the distortion to  
10 residual stresses and then the clamp/machine process again repeated until the final profile is achieved. The present invention allows closer approximation to that final profile or even achievement of that final profile with reduced machining steps and intervening release of the component to  
15 relieve residual stresses. In such circumstances, the present arrangement and method facilitate greater efficiency of component machining operations from originally forged components.

20 Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not  
25 particular emphasis has been placed thereon.